Decision-Making II

Choosing between Gambles

Neural basis of Decision-Making

Do we always make the best possible decisions?

- **Normative (or prescriptive) theories**: tell us how we should make rational decisions
  - E.g. optimize financial gain

- **Descriptive theories**: tell us how we actually make decisions, not on how we should make them

- Behavior can deviate from normative account in systematic ways

What are rational decisions?

- Decisions that are internally **consistent**
  - E.g.,
    - ✓ if A>B, then B<A
    - ✓ if A>B, B>C, then A>C (**transitivity**)

- Decisions that optimize some criterion
  - E.g. financial gain (**classic expected utility theory**)

Example

- What is the best choice?
  - A) .50 chance of winning $20
  - B) .25 chance of winning $48

Classic Expected Utility Model

- The **utility** of an outcome is a numerical score to measure how attractive the value associated with an outcome to the decision-maker

- In classic expected utility model, we assume that **utility = value**

Classic Expected Utility Model

- The **expected utility** is the summed utility of a each outcome, weighted by the probability of the outcome occurring

$$\text{Expected Utility} = \sum p(x_i)u(x_i)$$

probability *utility*

- A rational decision-maker should always choose the alternative that has the **maximum expected utility**

Example (1)

- Gamble: if you roll a 6 with a die, you get $4. Otherwise, you give me $1

- Take the gamble?

- Expected utility
  = p(win)*u(win) + p(lose)*u(lose)
  =(1/6)*(4)+ (5/6)*(-1)
  =-1/6

- So...do not take bet

Example (2)

- Which job would you accept:
  - Job A:
    - ✓ 50% chance of a 20% salary increase in the first year
  - Job B:
    - ✓ 90% chance of a 10% salary increase in the first year

- The classic expected utility model predicts Job A to be better (0.5 x 0.2 > 0.9 x 0.1)

Limitations of the Classic Expected Utility Model

- We can make “bad decisions” -- that is, decisions that do not make sense according to the expected utility model
  - Violations of **transitivity**
  - **Framing effects** （表达效应，框架效应）

Violations of Transitivity

- **Transitivity**: If you prefer A to B and B to C then you should prefer A to C
- Experiment included the following gambles:

Gamble	Probability of winning	Payoff	Expected value
A	7/24	5.00	1.46
B	8/24	4.75	1.58
C	9/24	4.50	1.69
D	10/24	4.25	1.77
E	11/24	4.00	1.83

- Result: subjects preferred:
  - A>B, B>C, C>D, D>E, but also E > A

Tversky, 1969

Violations of Transitivity

- Violations of transitivity can be explained by changes in the focus of attention. Sometimes people focus more on the differences in payoff in any adjacent gambles in the table (when the differences in probability are small). However, when the differences in probability become more extreme, people start paying attention to probability (as well as expected value)

Tversky, 1969

Framing effect

- Problem 1:
  - Select one of two prizes
    - ✓ (36%) An elegant Cross pen
    - ✓ (64%) $6

- Problem 2:
  - Select one of three prizes
    - ✓ (46%) An elegant Cross pen
    - ✓ (52%) $6
    - ✓ (2%) An inferior pen

Shafir & Tversky 1995

Example: Cheeseburgers

50% **50%**

Example: Cheeseburgers

Decisions can change when other options are added – people make different choices depending on how the problem is described

30% **60%** **10%**

Framing effect

- Version A: Imagine that you have decided to see a play where admission is $10 per ticket. As you enter the theater you discover that you have lost a $10 bill. Would you still pay $10 for a ticket for the play? **Yes 88% No 12%**
- Version B: Imagine that you have decided to see a play and paid the admission price of $10 per ticket. As you enter the theater you discover that you have lost the ticket. The seat was not marked and the ticket cannot be recovered. Would you pay $10 for another ticket?

Yes 46% No 54%

People think of money as belonging to certain categories, but it is really all the same money

Tversky & Kahneman, 1981

Framing effect

- Problem 1 “二鸟在林，不如一鸟在手”
  - Suppose I give you $300, but you also have to select one of these two options:

(72%) ✓ 1.0 chance of **gaining** $100

(28%) ✓ .50 chance of **gaining** $200 and a .50 chance of **gaining** nothing

- Problem 2 “赌一把”
  - Suppose I give you $500, but you also have to select one of these two options:

(36%) ✓ 1.0 chance of **losing** $100

(64%) ✓ .50 chance of **losing** $200 and a .50 chance of **losing** nothing

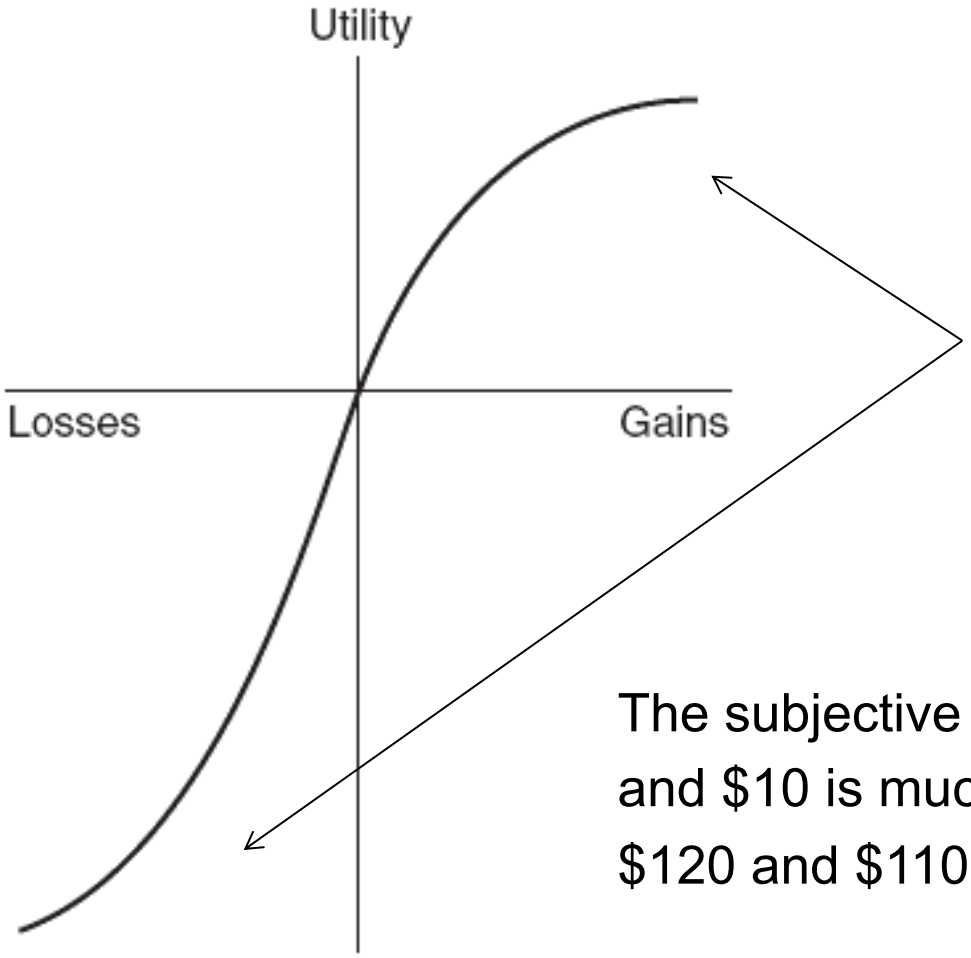
Tversky & Kahneman, 1986

Prospect Theory

- For most people, the utility of an amount of money is not equivalent to the monetary value, it is based on the **subjective utility**
- Example:
  - What is the best choice?
    - ✓ (A) .10 chance of winning $10 million dollars
    - ✓ (B) .99 chance of winning $1 million dollars
- Each additional dollar added to wealth brings less utility
  - ("diminishing marginal utility effect")

It is better to distinguish between classic expected utility model where probabilities and utilities are based on objective outcomes and subjective utility model (as in prospect theory) based on subjective probabilities and utilities

Prospect Theory

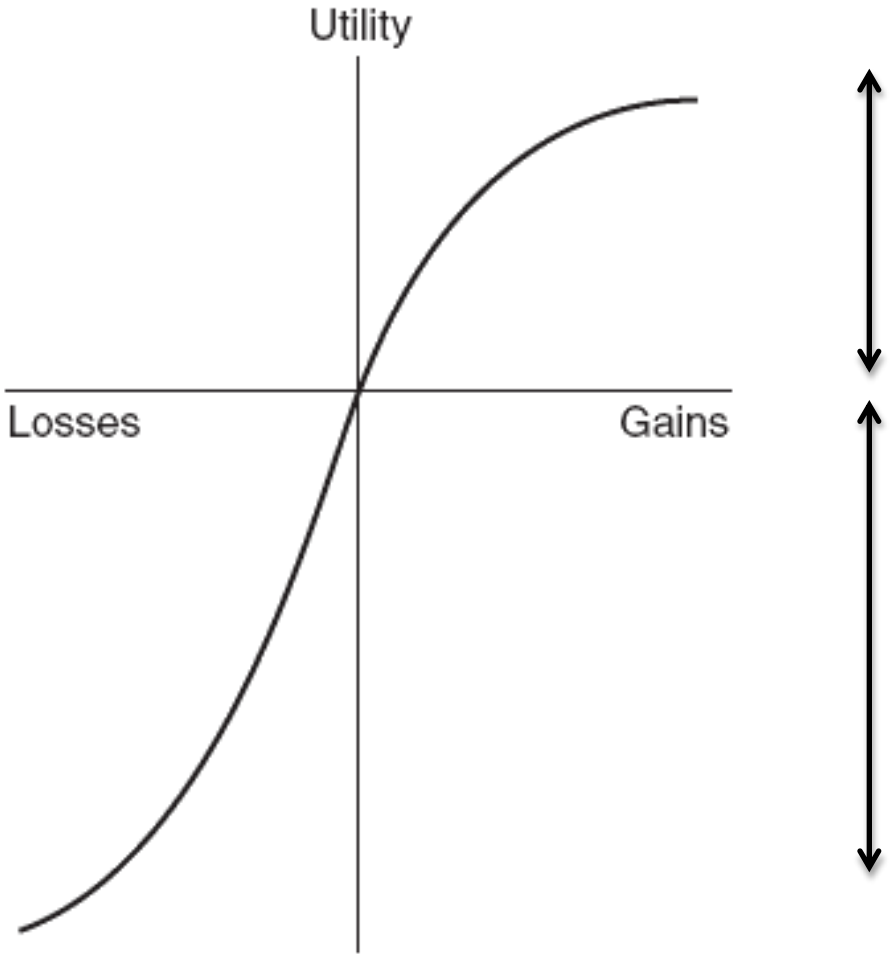


Diminishing marginal utility（边际效用递减）: additional gains (or losses) are not valued as much as early gains (or losses)

The subjective difference between $20 and $10 is much higher than between $120 and $110

A hypothetical function relating subjective utility to value

Prospect Theory



Loss-aversion

the negative effect of a loss is larger than the positive effect of a gain

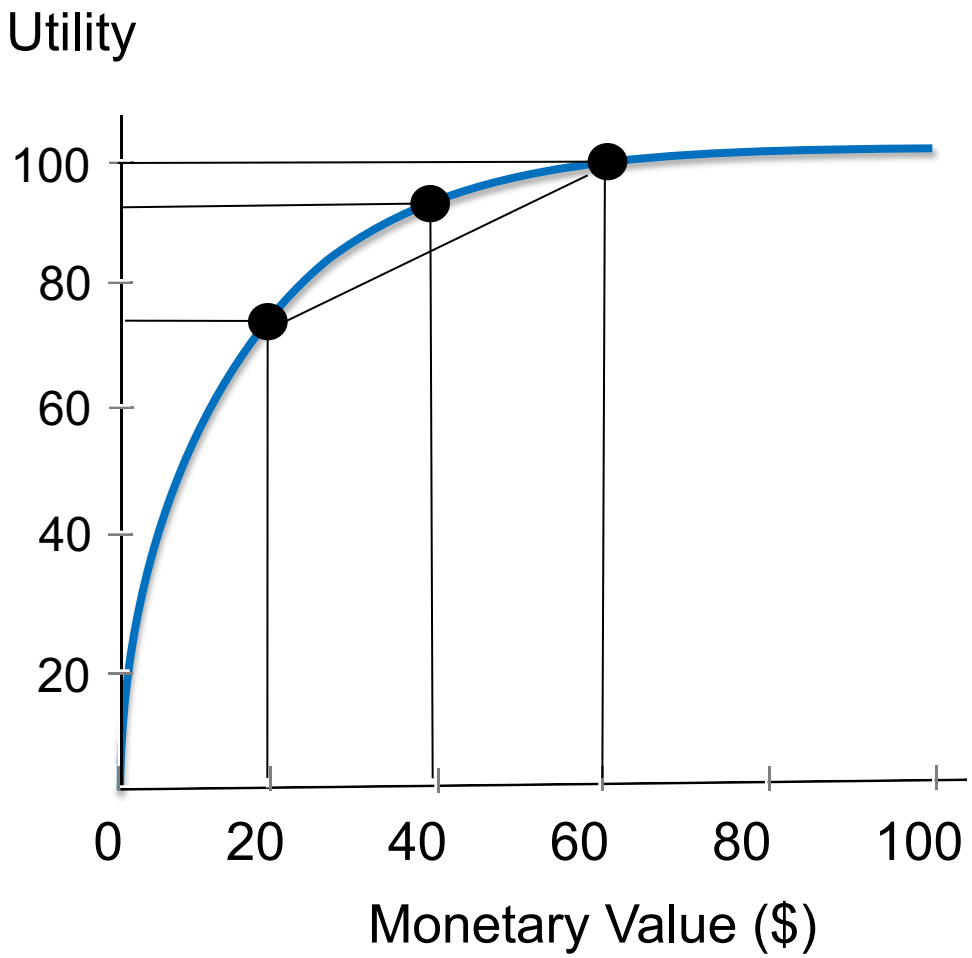
Risk Aversion for Gains

Example

Gamble 1:
win $20 with 50% chance
or $60 with 50% chance

Gamble 2:
win $40 with 100% chance

Risk Aversion for Gains



Example

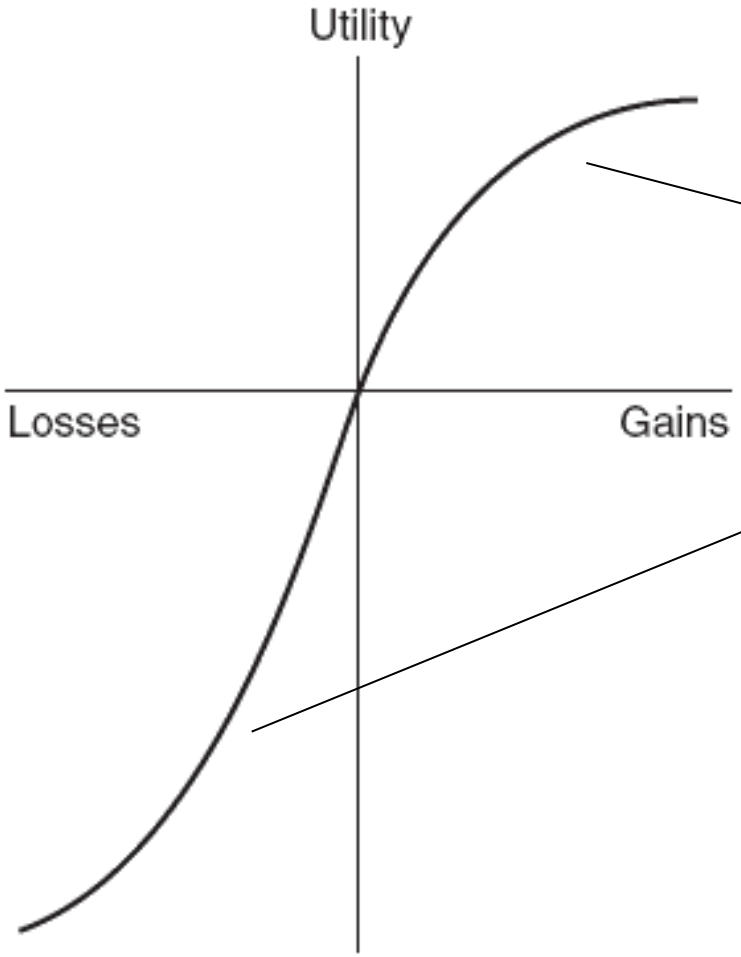
Gamble 1:
win $20 with 50% chance
or $60 with 50% chance

Gamble 2:
win $40 with 100% chance

What would a person choose with the subjective utility function shown on left?

Gamble 1: 74x0.5+100x0.5=87 < Gamble 2: 92x1=92

Prospect Theory



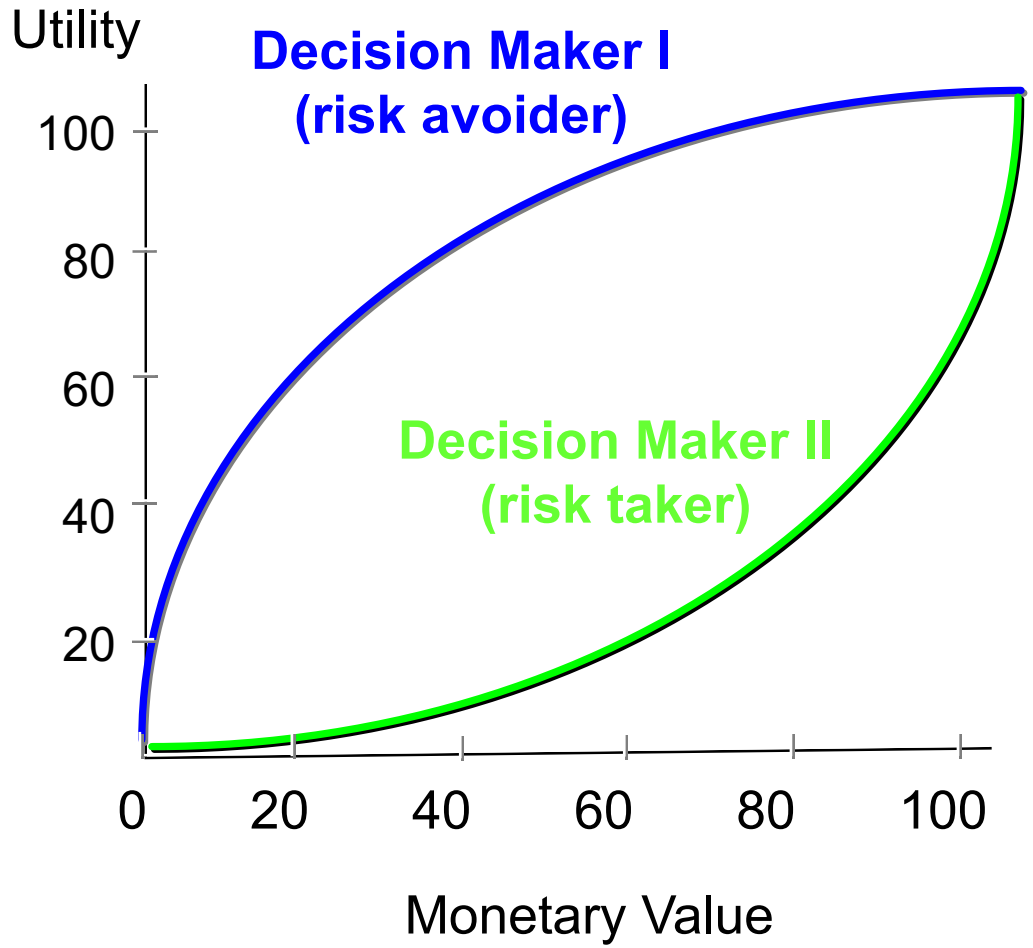
concave utility function for gains:

Risk-aversion for gains

convex utility function for losses:

Risk seeking for losses

Individual Differences



A risk taker, such as a gambler, pays a premium to obtain risk. His/her utility function is convex. This reflects the decision maker's increasing marginal value of money.

Subjective Probability

- The probability of an event might not be based on objective statistical calculations but might be based on a subjective estimate

- Overweighting of small probabilities and underweighting of likely outcomes

Rationality up to a point

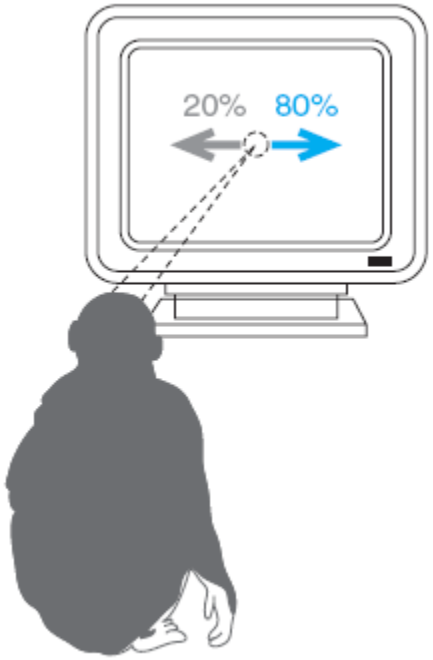
- People have limitations in memory and time

- Simon (1957)
  - **Bounded rationality**
    - ✓ We are rational, but within limits of human processing capabilities
  - **Satisficing**
    - ✓ We choose the first option that meets our minimum requirements

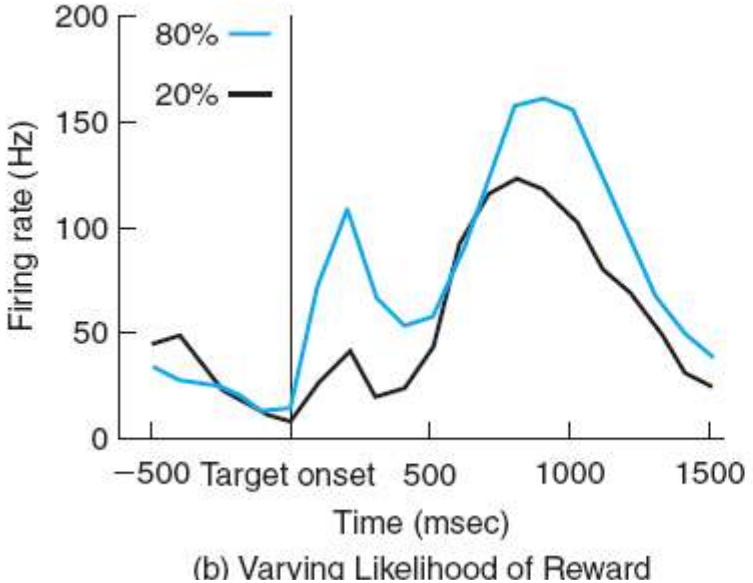
people might satisfice when making decisions such as buying a car

Neural Basis of Decision-Making

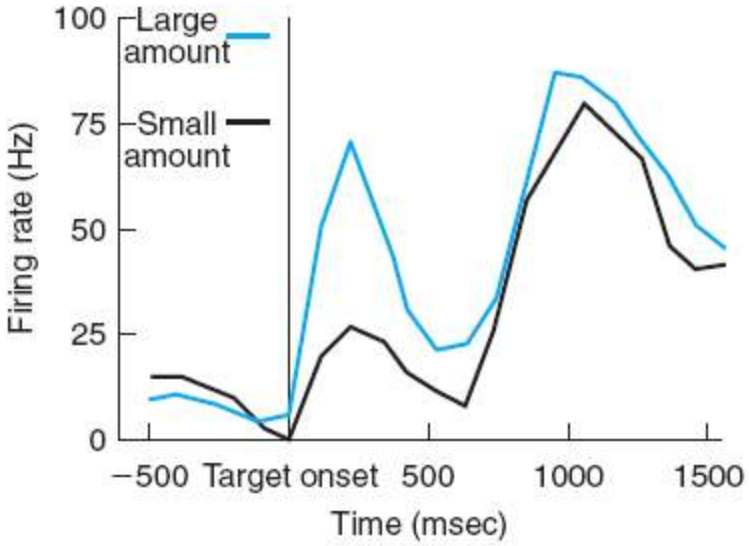
Neural Bases Of Expected Utility Calculations



(a) The Set-Up



(b) Varying Likelihood of Reward

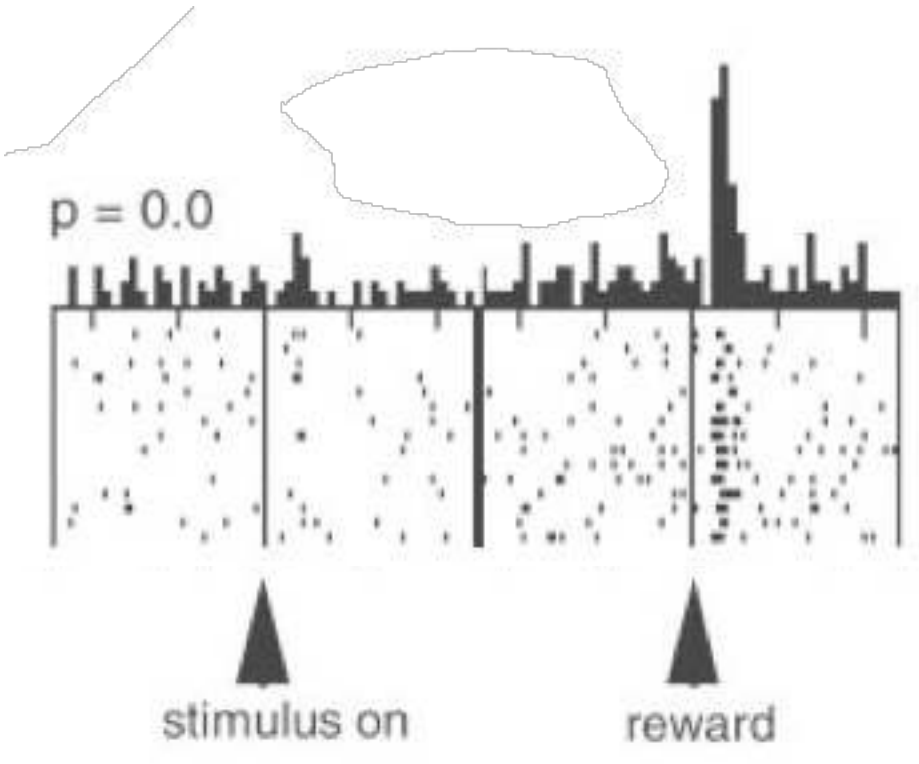


(c) Varying Amount of Reward

individual neurons in the lateral intraparietal cortex（外侧顶内沟皮层）were active before the reward was given

Glimcher, 2003

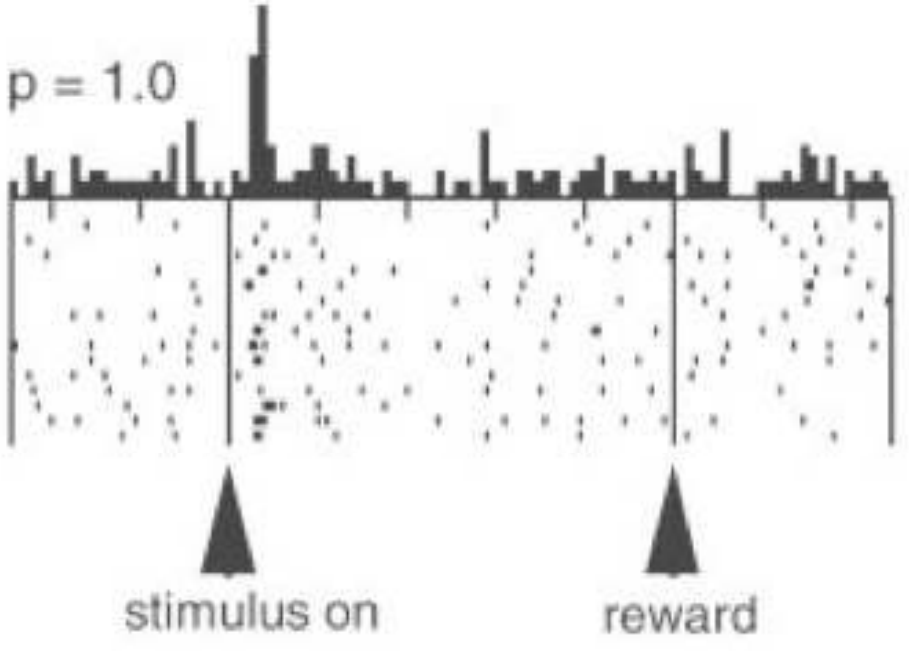
Surprise reactions in neurons



Reward is delivered despite having never been delivered (for this stimulus) in the past

Fiorillo, Tobler, and Schultz. *Science*. 2003

Anticipation of reward for same neurons

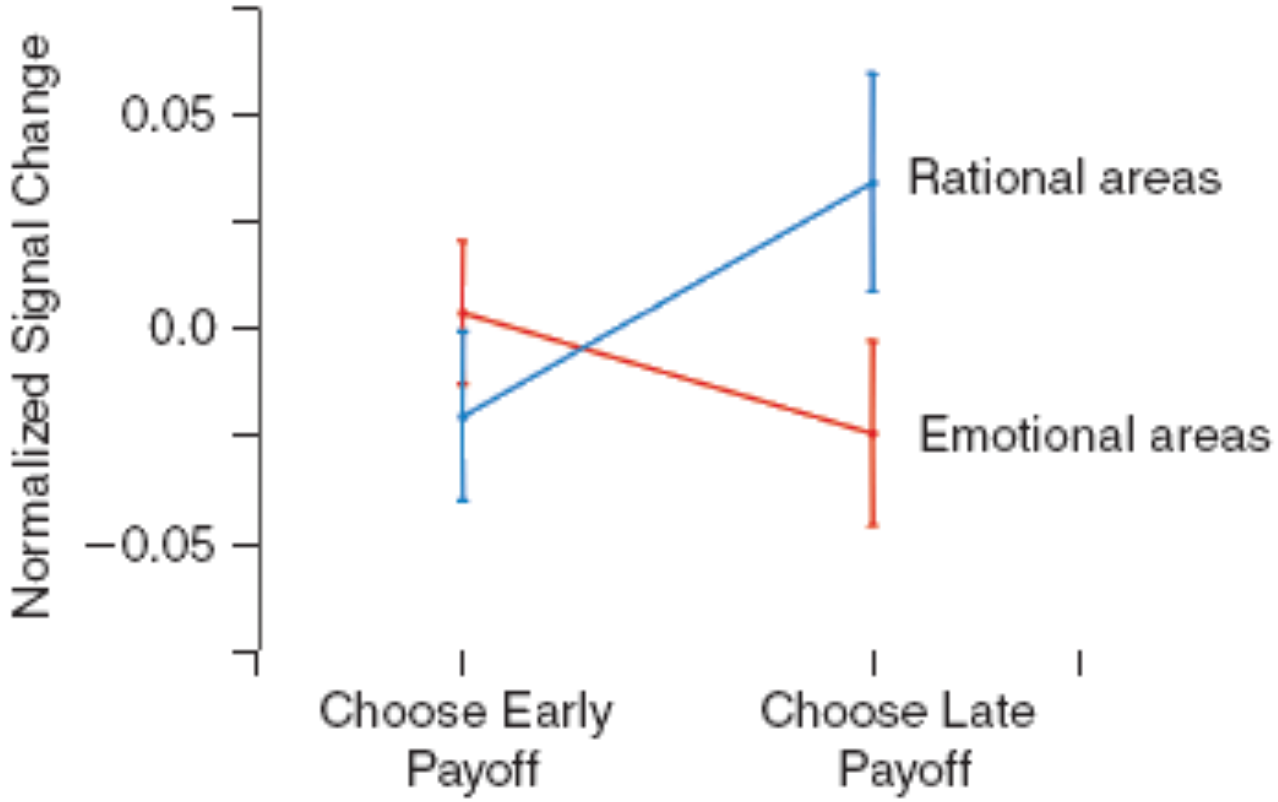


Reward will be delivered with probability one

Fiorillo, Tobler, and Schultz. *Science*. 2003

Involvement of Emotional Areas in Decisions

fMRI study



McClure et al., 2004

The Iowa Gambling Task

Four decks:

A B C D

On each trial, the participant has to choose a card from one of the decks.
Each card carries a reward, and, sometimes, a loss…

The Iowa Gambling Task

Four decks:

A	B	C	D
+$100 −$350			

Each deck has a different payoff structure, which is unknown to the participant. In order to maximize overall gain, the participant has to discover which decks are advantageous and which are not.

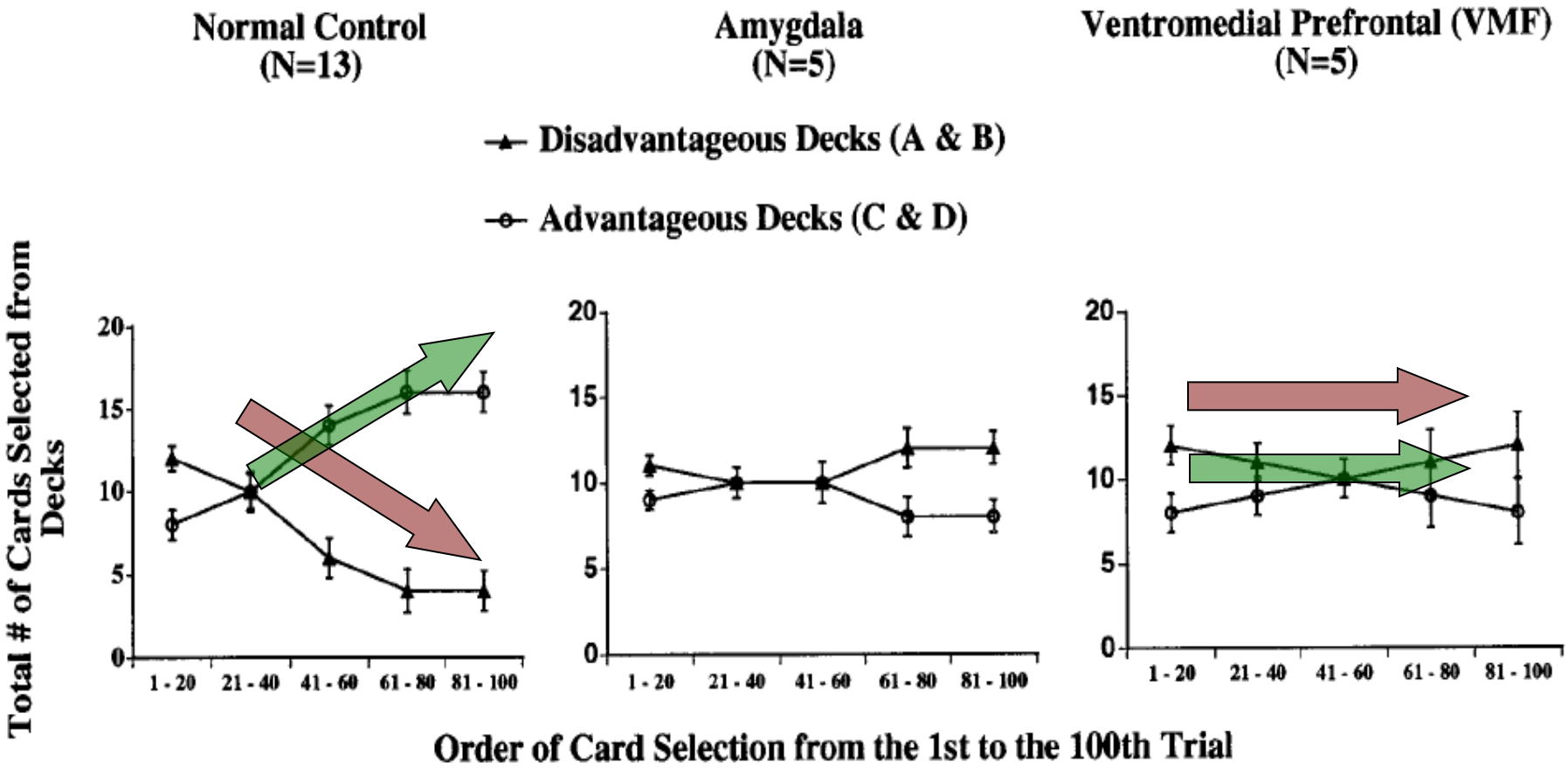
The Iowa Gambling Task

Bad Decks | Good Decks

	A	B	C	D
				
Reward per card	$100	$100	$50	$50
Av. loss per card	$125	$125	$25	$25

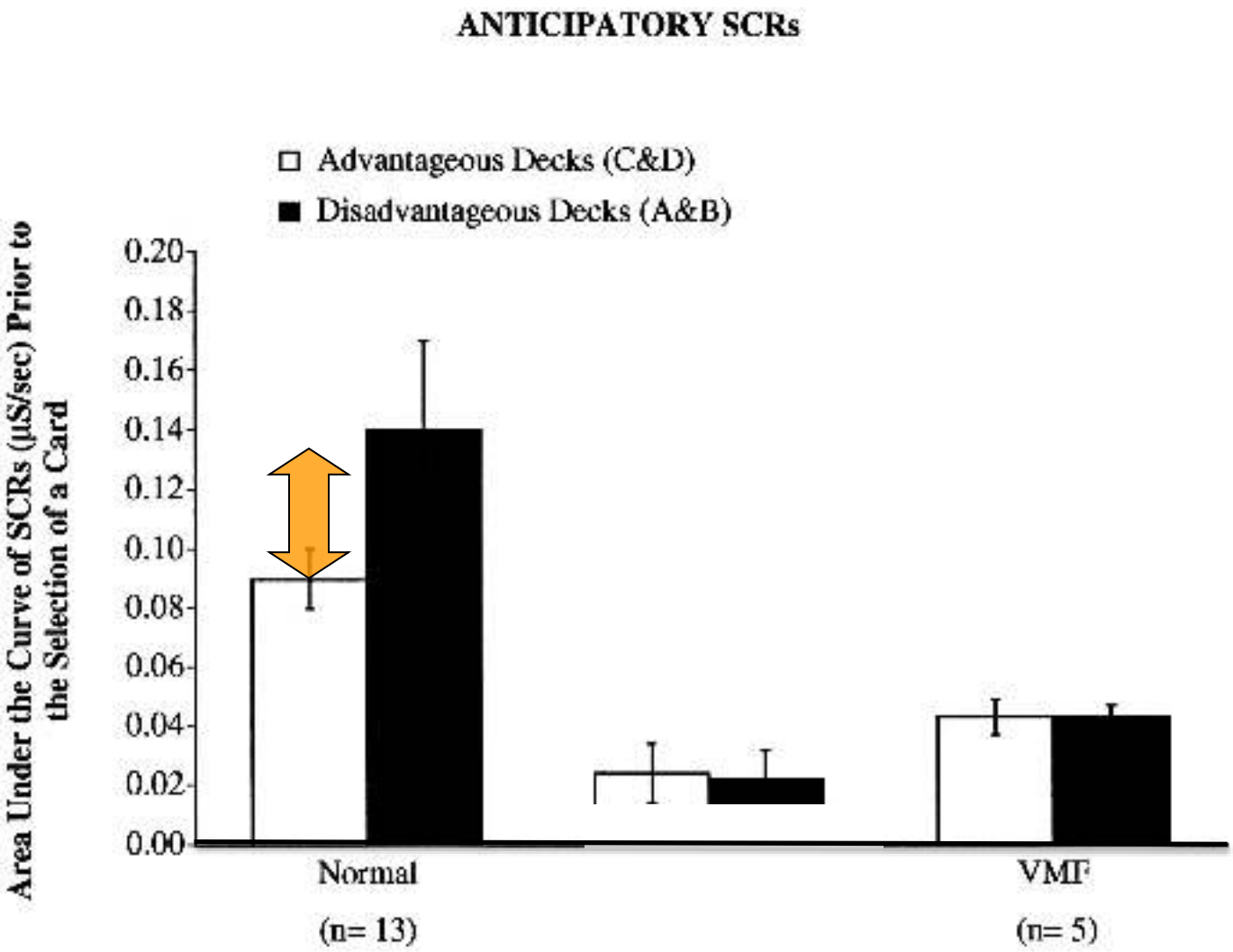
Behavioral Results with Normals and Patients with Ventromedial Prefrontal Damage

（腹内侧前额叶）



Bechara et al., 1999

Skin conductance results in same experiment



Bechara et al., 1999

Results

- Normal (control) participants learned how to maximize wins
  - Showed elevated SCR responses in anticipation of a potential large loss

- Patients with ventromedial PFC damage:
  - Performed poorly on task (stuck with bad decks)
  - Did not show elevated SCR responses before poor choices